CREOSOTE - ECOLOGICAL EFFECTS
AND
ENVIRONMENTAL RISK CHARACTERIZATION

EXECUTIVE SUMMARY

The toxicity of creosote to wildlife and plants is difficult to characterize as there is a very limited amount of data available that addresses this topic. No ecotoxicity studies have been submitted to the Agency in support of the reregistration of creosote. Additionally, none of the creosote ecotoxicity data identified in the open literature fully addresses FIFRA guideline requirements. In most cases, the data were not developed to directly address the hazards identification or risk issues. However, we have made inferences about the results to fit data requirements. In addition, the specific composition of the creosote used in the studies was not given by the researchers. This made it difficult to compare the results of different studies and to relate these results to fate information. Further complicating matters, the environmental fate data were developed for the component polycyclic aromatic hydrocarbons (PAHs) and not for whole creosote, again making it difficult to relate the exposure and effects results, particularly in calculating Risk Quotients (RQs). However, RQs were calculated for acute effects on aquatic organisms and chronic effects on freshwater fish using surface water estimated environmental concentrations (EECs). These EECs were calculated for five of the PAHs found in creosote using the Generic Expected Environmental Concentrations (GENEEC) computer model. The LC_{50} values used in the RQ calculations were from studies that used whole creosote as the test substance. None of the levels of concern were exceeded using these values.

The Agency has concluded that risk to birds and terrestrial mammals is probably minimal, due to lack of exposure and the ability of these organisms to avoid creosote. Risk to terrestrial plants would also be considered minimal due to lack of exposure. However, risk to freshwater and marine/estuarine aquatic organisms is harder to quantitate using these data. Certainly there will be some exposure due to leaching from the treated wood into the aquatic environment; however, determining the amount of exposure and the amount of toxicity due to this exposure is difficult using the data at hand. The RQ values calculated with the available data do not demonstrate a concern for acute effects on aquatic organisms or chronic effects on freshwater fish. However, the EECs were calculated for the component PAHs, while the aquatic toxicity data were generated using whole creosote. The available data found in the open literature were not adequate to supply the information needed to assess chronic effects to freshwater invertebrates or to marine/estuarine aquatic organisms. It is not possible, therefore, to determine the chronic risk creosote may present to freshwater invertebrates and marine/estuarine aquatic organisms, including endangered species. However, the data indicate that creosote does not exceed the level of concern for acute toxicity to fish and aquatic invertebrates or for chronic toxicity to freshwater fish.

Certain studies from the open literature describe effects on organisms which suggest that creosote may be an endocrine disruptor. EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all

pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally-occurring estrogen, or other such endocrine effects as the Administrator may designate." Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific basis for including, as part of the program, the androgen and thryoid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use FIFRA and, to the extend that effects in wildlife may help determine whether a substance may have an effect in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP). When the appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, creosote may be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption.

The Agency has developed the Endangered Species Protection Program to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that address these impacts. The Endangered Species Act requires federal agencies to ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat. To analyze the potential of registered pesticide uses to affect any particular species, EPA puts basic toxicity and exposure data developed for risk assessments into context for individual listed species and their locations by evaluating important ecological parameters, pesticide use information, the geographic relationship between specific pesticide uses and species locations, and biological requirements and behavioral aspects of the particular species. A determination that there is a likelihood of potential impact to a listed species may result in limitations on use of the pesticide, other measures to mitigate any potential impact, or consultations with the Fish and Wildlife Service and/or the National Marine Fisheries Service as necessary.

The Agency is currently engaged in a Proactive Conservation Review with USFWS and the National Marine Fisheries Service under section 7(a)(1) of the Endangered Species Act. The objective of this review is to clarify and develop consistent processes for endangered species risk assessments and consultations. Subsequent to the completion of this process, the Agency will reassess the potential effects of creosote use to federally listed threatened and endangered species. Until such time as this analysis is completed, the overall environmental effects mitigation strategy articulated in this document and any County Specific Pamphlets described in Section 7 of the Endangered Species Act which address creosote or other wood preservatives will serve as interim protection measures to reduce the likelihood that endangered and threatened species may be exposed to creosote at levels of concern.

VI. SCIENCE ASSESSMENT - ECOLOGICAL EFFECTS

A. Ecological Effects Hazard Assessment

1. Ecological Toxicity Data

a. Toxicity to Terrestrial Animals

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of creosote to birds. The preferred test species is either mallard duck (a waterfowl) or bobwhite quail (an upland game bird). The registrants have not submitted any studies addressing acute or subacute avian toxicity.

References to two avian toxicity studies have been found in the open literature. One is an oral acute toxicity study (Webb, 1975), and the other is a dietary study (Webb, 1990). The actual studies were not reviewed, but the results were reported to be inconclusive in determining toxicity to both the bobwhite quail (*Colinus virginianus*) and the Mallard duck (*Anas platyrhynchos*). The birds in these studies apparently avoided consumption of the food-creosote mixture (Webb, 1975 and 1990).

Therefore, no data are available to assess the acute and subacute toxicity of creosote to avian species.

ii. Birds, Chronic

Avian reproduction studies using the TGAI may be required for creosote if the following criteria are met: (1) birds may be subjected to repeated or continuous exposure to the pesticide or any of its metabolites or degradation products, especially preceding or during the breeding season; (2) the pesticide or any of its major metabolites or degradation products are stable in the environment to the extent that potentially toxic amounts may persist in avian feed items; (3) the pesticide or any of its major metabolites or degradation products is stored or accumulated in plant or animal tissues, as indicated by its octanol/water partition coefficient, accumulation studies, metabolic release and retention studies or as indicated by structural similarity to known bioaccumulative chemicals; (4) any other information, such as that derived from mammalian reproduction studies, that indicates the reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the pesticide product.

No studies were submitted or evaluated under this topic. Such data are not required at this time due to the likelihood of minimal chronic avian exposure.

iii. Mammals, Acute and Chronic

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's health Effects Division (HED) substitute for wild mammal testing. Data indicate that creosote has a moderate to very low level of acute oral toxicity to mice (LC_{50} = 433-725 mg/kg body weight) and rats (LD_{50} = 725-5,400 mg/kg body weight).

b. Toxicity to Freshwater Aquatic Animals

i. Freshwater fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of creosote to fish. The preferred test species are rainbow trout (a cold water fish) and bluegill sunfish (a warm water fish).

Data on the toxicity of creosote to freshwater fish in the open literature are very limited. Five studies have been identified which test the toxicity of creosote to the preferred test species. The results of these studies are presented in the following table:

TABLE 1: Acute Toxicity of Creosote to Freshwater Fish

Substance	Organism/ Life stage	Endpoints/ Results (mg/L)	Comments	Reference
creosote- coal tar solution (60/40)	rainbow trout juvenile	96h LC_{50} = 0.88 LOEC = NA NOEC = 0.49	Static, nominal concentrations	Webb, 1975
marine grade creosote (P13)	rainbow trout juvenile	96h LC_{50} = 0.56-0.75 LOEC = NA NOEC = 0.75	Static, nominal concentrations	Webb. 1975
creosote - coal tar solution (60/40)	bluegill sunfish juvenile	96h LC_{50} = 0.99 LOEC = NA NOEC = 0.75	Static, nominal concentrations	Webb, 1975
creosote (Koppers Inc. P1/P13) in rainfall leachate from 15 bundled pilings	rainbow trout juvenile	96h LC_{50} TPAH[1] = 0.043 - 0.204 96h LC_{50} phenolics = 0.387 - 0.654 (3-15% pilings leachate)	NOEC and LOEC not determined	Whiticar et al, 1994
creosote (Koppers Inc. P1/P13) in rainfall leachate from 12 bundled timbers	rainbow trout juvenile	96h LC_{50} TPAH[1] = 0.002 - 0.203 96h LC_{50} phenolics = 0.022 - 0.228 (3-15% timbers leachate)	NOEC and LOEC not determined	Whiticar et al, 1994

[1] TPAH = Total Polyaromatic Hydrocarbons

Because these studies are from the open literature, they have not been reviewed by the Agency to determine whether they comply with Guideline requirements. All indicate that creosote would be classified as highly toxic to rainbow trout and bluegill sunfish. Unfortunately, the validity of these results is in question, because the results of the tests were reported as nominal instead of measured concentrations. This is a problem with creosote, because its hydrophobic fraction will precipitate out in water. This leads to actual measured dissolved creosote concentrations being much lower than the estimated nominal concentrations. The actual concentrations that the test species are dosed with have been shown to be as little as 28% of the estimated nominal concentrations. This can lead to an overestimation of the actual levels of dissolved and readily available creosote used the studies, which in turn leads to an underestimation of the toxicity of creosote to the exposed organisms. Therefore, the actual toxicity of creosote to the fish species tested in these studies cannot be accurately determined. Under these circumstances, these results introduce uncertainty in assessing the toxicity of creosote to freshwater fish. However, because these are the only data available, they have been used in our risk calculations.

ii. Freshwater Fish, Chronic

Fish early life stage tests are required if the product is applied directly to water or expected to be transported to water from the intended use site, and when any one or more of the following conditions apply: (1) if the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) if any LC_{50} or EC_{50} value determined in acute toxicity testing is less than 1 mg/L; or (3) if the estimated concentration in water is equal to or greater that 0.01 of any EC_{50} or LC_{50} determined in acute toxicity testing; (4) if the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any EC_{50} or LC_{50} determined in acute toxicity testing and any of the following conditions exist: (a) studies of other organisms indicate the reproductive physiology of fish and /or invertebrates may be affected; (b) physicochemical properties indicate cumulative effects; (c) the pesticide is persistent in water (e.g. half-life in water greater than 4 days). Fish early life-stage testing is required for creosote due to LC_{50} values of less than 1.0 mg/L and the likelihood of fish exposure to creosote due to creosote-treated wood being used in aquatic habitats.

Fish life cycle tests are required if the end-use product is intended to be applied directly to water or expected to transport to water from the intended use site, and when any of the following conditions apply: (1) if the estimated environmental concentration is equal or greater than one tenth of the no-effect level in the fish early life-stage or invertebrate life-cycle test; (2) if studies of other organisms indicate the reproductive physiology of fish may be affected.

iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of creosote to aquatic invertebrates. The preferred test species is *Daphnia magna.*

Two studies have been identified in the open literature that test the effects of creosote on aquatic invertebrates. The actual studies were not available for review. The results indicate that creosote would be toxic to *Daphnia*. However, the concentrations of creosote were not measured in the studies, so it is impossible to determine the actual amounts of creosote used in the tests. Therefore, the actual toxicity of creosote to daphnids may be significantly higher than is indicated in these studies. These studies introduce uncertainty when used in a risk assessment for the effects of creosote on aquatic invertebrates; however, because they are the only data available, they have been used in our risk calculations.

TABLE 2: Acute Toxicity of Creosote to Freshwater Aquatic Invertebrates

Substance	Organism/ Life stage	Endpoints/ Results (mg/L)	Comments	Reference
creosote (unknown grade)	*Daphnia pulex* neonates	48h LC_{50} = 2.91% of WSF(dilution) LOEC = NA NOEC = NA life cycle LOEC = 1.0% of WSF	Static renewal (24 hr intervals) concentration not measured/not enough data to estimate	***Geiger & Buikema 1981, 1982***--need to add to references
creosote (unknown grade)	*Daphnia magna* neonates	48h LC_{50} = 1.93 (Direct A)[1] 48h LC_{50} = 3.47 (Direct B)[1] LOEC = NA NOEC = NA	Static renewal, whether concentrations measured is uncertain	Tadokoro et al, 1991

[1]Direct A: creosote added directly to test media, no cosolvent. Direct B: same as Direct A, but supernatant use in study. Dilution: creosote added to stock solution, stirred to reach equilibrium, water soluble fraction (WSF) extracted then added to bioassay.

iv. Whole Sediment Acute Invertebrate, Freshwater

Whole sediment acute invertebrate, freshwater studies (1) may be required when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited: (2) may be required on a case-by-case basis depending on the results of lower tier ecological studies (e.g., active ingredient or end-use products are highly toxic to aquatic organisms) and/or pertinent environmental characteristics (e.g., Kow is greater than or equal to ($\geq$) 1,000 or hydrolysis half-life is greater than (>) 5 days); and (3) required for organic-based compounds with a Koc (organic carbon coefficient) greater than (>) 1,000 and solubility is less than, or equal to, ($\leq$) 0.1 mg/ml. Several of the individual polycyclic aromatic hydrocarbons (PAHs) which comprise creosote meet the above environmental fate criteria for requiring testing. Available data regarding the acute toxicity of creosote does not indicate high toxicity to freshwater invertebrates, but does indicate high toxicity to freshwater fish. Whole sediment acute testing is therefore required. Because this data is not available, either as submitted studies or from the open literature, the risk to invertebrates from exposure to creosote contaminated sediment cannot be addressed at this time.

v. Freshwater Invertebrate, Chronic

A freshwater invertebrate life-cycle test using the TGAI is required for creosote when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited and when any of the following conditions apply: (1) if any LC_{50} or EC_{50} value determined in acute toxicity testing is less than 1 mg/L; (2) if the estimated environmental concentration is water is greater than or equal to ($\geq$) 0.01 of any EC_{50} or LC_{50} determined in acute toxicity testing; (3) if the actual or estimated environmental concentration in water is less than 0.01 of any EC_{50} or LC_{50} determined in acute toxicity testing and any of the following conditions exist: (a) studies of other organisms indicate the reproductive physiology of fish/invertebrates may be affected; (b) physicochemical properties indicate cumulative effects may occur and/or; (c) the pesticide is persistent in water. The preferred test species is *Daphnia magna*.

One chronic study (Geiger and Buikema, 1982) was found in the open literature (see above table). *Daphnia magna* neonates were dosed with the WSF of creosote prepared using the dilution method. The results demonstrated an LOEC of 1.0% WSF, which caused a significant reduction in growth rates, production of viable eggs and live young, and an increase in partial and full abortions. There was not enough information to translate the percentage of WSF to a water concentration. This makes the data of little value in calculating a quantitative estimate of risk, but we have considered the results of this study in a qualitative manner in our risk assessment.

vi. Acute Pore Water, Fish and Invertebrates

An acute pore water, fish and invertebrates study may be required when (1) treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited; (2) on a case-by -case basis, depending on the results of lower tier ecological studies (e.g., active ingredient or end-use products are highly toxic to aquatic organisms) and /or pertinent environmental characteristics (e.g., Kow is greater than or equal to ($\geq$) 1,000 or hydrolysis half-life is greater than (>) 5 days); and (3) required for organic-based compounds with a Koc (organic carbon coefficient) greater than (>) 1,000 and solubility is less than, or equal to, ($\leq$) 0.1 mg/l. Several of the individual polycyclic aromatic hydrocarbons (PAHs) which comprise creosote meet the above environmental fate criteria for requiring testing. Available data regarding the acute toxicity of creosote does not indicate high toxicity to freshwater invertebrates, but does indicate high toxicity to freshwater fish. Acute pore water testing is therefore required. This data is not available as submitted studies or from the open literature; therefore, the risk to fish and aquatic invertebrates from exposure to creosote contaminated pore water cannot be addressed at this time

vii. Freshwater Field Studies

Simulated or actual field testing may be required on a case-by-case basis depending on the results of lower tier ecological studies (e.g., active ingredient or end-use products are highly toxic to aquatic organisms) and/or pertinent environmental characteristics (e.g., Kow is greater than or equal to ($\geq$) 1,000 or hydrolysis half-life is greater than (>) 5 days). Field testing for aquatic organisms is required when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited. Several of the PAHs which comprise creosote meet these environmental fate criteria, and creosote has also been shown to be highly toxic to fish. Therefore, aquatic field testing is required for creosote. This data was unavailable at the time of this risk assessment, so the potential impact of creosote-treated wood to organisms in aquatic habitats cannot be fully assessed at this time.

c. Toxicity to Estuarine and Marine Animals

i Estuarine and Marine Fish, Acute

Acute toxicity testing with estuarine/marine fish using the TGAI is required for creosote because the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species is sheepshead minnow. No studies have been submitted to the Agency under this topic; however ,two studies were found in the open literature addressing the acute toxicity of creosote to marine fish. These are summarized in the following table:

TABLE 3: Acute Toxicity of Creosote to Marine/Estuarine Fish

Substance	**Organism/ Life Stage**	**Endpoints/ Concentration (mg/L)**	**Comments**	**Reference**
creosote (marine grade)	Sheepshead minnow *Cyprinodon variegatus* 9 mm long	96h EC_{50} = 0.72 LOEC = NA NOEC = NA	Static, nominal concentrations, filtered seawater, triethylene glycol cosolvent, mortality endpoint	Borthwick and Patrick, 1982
creosote (marine grade)	Sheepshead minnow *Cyprinodon variegatus* 12 mm long	96h EC_{50} = 3.5 LOEC = NA NOEC = NA	flow through, nominal concentrations, filtered seawater, acetone cosolvent, mortality endpoint[1]	Borthwick and Patrick, 1982

[1]actual dissolved concentration likely lower due to presence of “surface slick and black precipitate”

Creosote is highly to moderately toxic to the sheepshead minnow, based on the results from the above studies. However, the results were reported as nominal concentrations and were not measured. As explained in the previous section (b. toxicity to freshwater aquatic organisms), actual dissolved creosote concentrations may represent as little as 28% of the estimated nominal concentrations. Additionally, studies using a cosolvent to prepare the stock solutions of creosote are not representative of natural situations. The actual toxicity may therefore be higher than this study indicates.

Additional studies have documented the effects of creosote contaminated sediments at Eagle Harbor, WA to bottomfish (Johnson et al.,1994; Myers et al., 1987; Krahn et al. 1986; and Malins et al. 1984). These have included accumulation in tissues and body fluids, increased activities of xenobiotic metabolizing enzymes, binding of chemical carcinogens to DNA in the liver, and pathological conditions including liver disease (Johnson et al, 1994).

Another study in Eagle Harbor, WA investigated the effects of creosote on English sole, *Parophrys vetulus* (Malins et al., 1985). The authors reported a high incidence of hepatic neoplasm, such as hepatocellular carcinomas, lever cell adenomas, cholangiocellular carcinoma, and mixed hepatocellular cholangiocellular carcinoma.

Additional research demonstrated a strong statistical association between liver lesions in the fish and exposure to PAHs in Puget Sound (Myers et al., 1990). These results help to support the link between sediment PAH contamination and idiopathic liver diseases in bottom-dwelling fish (Krahn et al., 1986) .

ii. Estuarine and Marine Fish, Chronic

An estuarine and marine fish early life-stage toxicity test using the TGAI is required for creosote when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited and when any of the following conditions apply: (1) if any LC_{50} or EC_{50} value determined in acute toxicity testing is less than 1 mg/L, (2) if the estimated environmental concentration is water is greater than or equal ($\geq$) to 0.01 of any LC_{50} or EC_{50} value determined in acute toxicity testing, (3) if the actual or estimated environmental concentration in water is less than 0.01 of any acute LC_{50} or EC_{50} value determined in acute toxicity testing and any of the following conditions exist: (a) studies of other organisms indicate the reproductive physiology of fish/invertebrates may be affected; (b) physicochemical properties indicate cumulative effects may occur; or (c) the pesticide is persistent in water. The preferred test species is the sheepshead minnow. The use sites, chemical properties, and toxicity of creosote meet these criteria; however, no data under this topic have been submitted to the Agency.

Using data from Puget sound (Eagle Harbor), it has been established that sediment PAH contamination is associated with reproductive impairment in bottom dwelling fish (Johnson et al. 1988). In Eagle Harbor, adult female English sole underwent gonadal development at 60% while in less contaminated areas of Puget Sound the percentage increased to approximately 80 to 90%. The levels of TPAH found in these studies were 2.05 to 119.2 µg/g dry weight in sediment, 0.91 µg/g wet weight in liver and non-detectable residues in muscle of English sole. These results have been supported using laboratory studies. Creosote contamination reduced endogenous estradiol in gravid females of English sole. The females that do successfully enter vitellogenesis may experience inhibited spawning ability and reduced egg and larval viability (Casillas et al., 1991). English sole brought into the laboratory from Eagle harbor demonstrated significantly lower spawning success. **These types of effects indicate that creosote is a potential endocrine disruptor.** EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally-occurring estrogen, or other such endocrine effects as the Administrator may designate." Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific basis for including, as part of the program, the androgen and thryoid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use FIFRA and, to the extend that effects in wildlife may help determine whether a substance may have an effects in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP).

When the appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, creosote may be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption.

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using TGAI is required for creosote when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited. The preferred test species are the mysid and the Eastern oyster. Seven studies were identified in the open literature addressing acute effects of creosote on estuarine and marine invertebrates. The results of these studies are summarized in the following table:

TABLE 4: Toxicity of Creosote to Marine/Estuarine Invertebrates

Substance	**Organism/Life Stage**	**Endpoints/ Concentration (mg/L)**	**Comments**	**Reference**
creosote (marine grade)	Pink shrimp *Penaeus duorarum* 83 mm long	96h LC_{50} = 0.24 LOEC = NA NOEC = NA	Flow through, nominal concentrations, filtered seawater, acetone cosolvent, mortality	Borthwick and Patrick, 1982

TABLE 4: Toxicity of Creosote to Marine/Estuarine Invertebrates				
Substance	**Organism/Life Stage**	**Endpoints/ Concentration (mg/L)**	**Comments**	**Reference**
creosote (unknown grade)	Lobster, *Homarus americanus* adult	96h LC_{50} = 1.76 LOEC = NA NOEC = NA	Static renewal (48 hr intervals), nominal concentrations, hexane cosolvent	McLeese and Metcalfe, 1979
creosote (unknown grade)	Lobster, *Homarus americanus* larvae	96h LC_{50} = 0.2 LOEC = NA NOEC = NA	Static renewal (48 hr intervals), nominal concentrations, hexane cosolvent	McLeese and Metcalfe, 1979
creosote (unknown grade)	Crangonid shrimp, *Crangon septemspinosa* age unknown	96h LC_{50} = 0.13 LOEC = NA NOEC = NA	Static renewal (48 hr intervals), nominal concentrations, hexane cosolvent	McLeese and Metcalfe, 1979
creosote (unknown grade)	Crangoid shrimp, *Crangon* age unknown	96h LC_{50} = 0.11 LOEC = NA NOEC = NA	Static renewal (48 hr intervals), nominal concentrations, hexane cosolvent	McLeese and Metcalfe, 1979
creosote (marine grade)	Mysids *Mysidopsis bahia* 1 mm long	96h LC_{50} = 0.018 LOEC = NA NOEC = NA	Static, nominal concentrations, filtered seawater, triethylene glycol cosolvent, mortality	Borthwick and Patrick, 1982
creosote (marine grade)	Eastern Oysters *Crassostrea virginica* 36 mm long	96h EC_{50} = 0.71 LOEC = NA NOEC = NA	Flow through, nominal concentrations, filtered seawater, acetone cosolvent, shell deposition endpoint	Borthwick and Patrick, 1982

The results of these studies indicate that creosote is highly toxic to mysid, eastern oyster, pink shrimp, lobster larvae and crangonid shrimp, and moderately toxic to adult lobster. Again, as with the other studies found in the open literature, reported creosote concentrations were nominal and not measured. Actual dissolved concentrations may only represent only 28% of the estimated nominal concentrations. Also, the use of a cosolvent to prepare the stock solution of creosote does not represent natural situations. The actual toxicity of creosote to marine/estuarine invertebrates may therefore be greater than these studies indicate.

iv. Whole Sediment Acute Invertebrate, Marine

Whole sediment acute invertebrate, marine studies are required for uses in estuarine/marine environments and may be required when (1) treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited; (2) may be required on a case-by-case basis depending on the results of lower tier ecological studies (e.g., active ingredient or end-use products are highly toxic to aquatic organisms) and/or pertinent environmental characteristics (e.g., Kow is greater than or equal to ($\geq$) 1,000 or hydrolysis half-life is greater than (>) 5 days); and (3) required for organic-based compounds with a Koc (organic carbon coefficient) greater that (>) 1,000 and solubility is less than, or equal to ($\leq$) 0.1 mg/l.

There are studies in the literature which have investigated the effects of creosote contaminated sediments on estuarine and marine organisms. However, most of these studies did not test creosote-treated products, but instead examined creosote contaminated sediments from wood preservation facilities.

Vijayan and Crampton (1994) examined the effects of creosote from treated marine pilings on an estuarine amphipod *Eohaustorius esruarius*. The researchers used sediments gathered in the vicinity of creosote treated structures at Belcarra Bay and Westham Island. The sediment with higher TPAH concentrations had statistically significant lower amphipod survival rates when compared to the control. Since other non-creosote sources of PAH may have influenced amphipod survival and survival of this particular amphipod can be influenced by sediment characteristics, the results should be evaluated with some caution.

A second study, conducted in the Upper Lahave River, NS, examined hepatocytes of rainbow trout exposed to sediments taken from the vicinity of a newly treated wharf. Extracts from the sediments were found to be both genotoxic and cytotoxic to the hepatocytes (Gagne et al., 1995).

Creosote contaminated sediments from Eagle Harbor, WA were shown to have a 4 day LC_{50} of 666 µg TPAH/g wet wt. in the amphipod *Rhepoxynius abronius* (Swartz et al., 1989). After placing the amphipod into undiluted sediment samples, they immediately displayed abnormal swimming and all died within 10 to 60 minutes.

Uncontaminated and creosote-contaminated sand in aquaria (both field and laboratory colonized with macrobenthic animals) were compared to assess the effects of marine grade creosote on benthic community structure (Tagatz et al., 1983). Both the total number of individuals and species richness were significantly reduced compared to the control at creosote concentrations of 844 and 4420 µg/g dry wt. in the laboratory study. The field colonized communities had a significantly lower total population at the nominal creosote concentration of 177 µg/g dry wt. The lowest creosote concentration that reduced the numbers of individuals and species was 844 µg/g dry wt. for molluscs and 177 µg/g dry wt. for echinoderms, annelids and arthropods. Species diversity was found to be significantly lower than the control population at a creosote concentration of $\geq$ 844 ug/g dry wt. in both the field and laboratory- populated aquaria.

The effect of creosote contaminated sediments on aquatic organisms in the lower Willamette River was investigated using amphipod (*Hyalella azteca*) mortality and Microtox (*Photobacterium phosphoreum*) bioluminescence (Pastorok et al., 1994). The results showed toxicity within approximately 300 feet of the shoreline, with a highly toxic area near a dock used for creosote off-loading. A low presence of the contaminants in crayfish and a lack of serious liver lesions in sucker collected near the site suggest that risk to mobile species from chronic contamination is low. There was no evidence of adverse effects throughout the rest of the main channel of the river.

v. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle test using TGAI is required for creosote when treated wood will be used in the aquatic environment, or use in aquatic sites is not prohibited, and any of the following conditions apply: (1) if any LC_{50} or EC_{50} value determined in acute toxicity testing is less than 1 mg/L, (2) if the estimated environmental concentration in water is greater than or equal ($\geq$) to 0.01 of any LC_{50} or EC_{50} value determined in acute toxicity testing, (3) if the actual or estimated environmental concentration is water is less than 0.01 of any acute LC_{50} or EC_{50} value determined in acute toxicity testing and any of the following conditions exist: (a) studies of other organisms indicate the reproductive physiology of fish/ invertebrates may be affected; (b) physicochemical properties indicate cumulative effects may occur; or (c) the pesticide is persistent in water. The preferred test species is the mysid. Creosote meets the above criteria; however, no studies under this topic have been submitted to the Agency. No studies were found in the open literature that addressed chronic toxicity of creosote to estuarine and marine invertebrates. Due to the lack of data, the risk of chronic impacts to estuarine and marine invertebrates from the use of creosote cannot be assessed at this time.

vi. Whole Sediment Chronic, Invertebrates

Whole sediment chronic, invertebrate testing is required when morality exceeds 20% in any concentration level used in acute sediment testing.

Chronic effects to benthic invertebrates have been linked to marine sediments heavily contaminated with PAHs in the Elizabeth River Estuary, VA and Eagle Harbor, WA (Roberts et al., 1989; Malins et al., 1984).

d. Toxicity to Plants

i. Terrestrial Plants

Seedling emergence and vegetative vigor testing (terrestrial plant testing) is conditionally required for wood preservatives. This testing is required when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited. Only one plant species, rice (*Oryza sativa*), must be tested. Creosote meets the criteria for testing, since creosote-treated wood can be used in the aquatic environment. No terrestrial plant studies have been submitted to the

Agency, nor were any studies that addressed creosote toxicity to terrestrial plants found in the open literature. Therefore, the risk of creosote to terrestrial plants cannot be assessed at this time.

ii. Aquatic Plants

Aquatic plant testing is required for creosote when treated wood will be used in the aquatic environment or use in aquatic sites is not prohibited. The following species should be tested at Tier II: *Kerchneria subcapitata, Lemna gibba, Skeletonema costatum, Anabaena flos-aquae,* and a freshwater diatom. Creosote meets the criteria for testing, since creosote-treated wood can be used in the aquatic environment. No studies that addressed creosote toxicity to aquatic plants were submitted to the Agency or found in the open literature. The risk to aquatic plants from the use of creosote therefore cannot be assessed at this time.

B. Exposure Assessment

The exposure information used in the following risk assessment is described in detail in Appendix 10, "Environmental Modeling."

C. Ecological Risk Assessment

Risk assessment integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. One method of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** - potential for acute risk is high regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, AD does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD50 (birds and mammals (3) EC50 (aquatic plants and aquatic invertebrates) and (4) EC25 (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates) (2) NOEC (birds, fish and aquatic invertebrates) and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC value is used as the ecotoxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Risk presumptions, along with the corresponding RQs and LOCs are tabulated below.

Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Birds and Wild Mammals		
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOEC	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] $\frac{mg/ft^2}{LD50 * \text{wt. of bird}}$ [3] $\frac{\text{mg of toxicant consumed/day}}{LD50 * \text{wt. of bird}}$

Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/MATC or NOEC	1

[1] EEC = (ppm or ppb) in water

Risk Presumptions for Plants

Risk Presumption	RQ	LOC
Terrestrial and Semi-Aquatic Plants		
Acute High Risk	EEC[1]/EC25	1
Acute Endangered Species	EEC/EC05 or NOEC	1
Aquatic Plants		
Acute High Risk	EEC[2]/EC50	1
Acute Endangered Species	EEC/EC05 or NOEC	1

[1] EEC = lbs ai/A
[2] EEC = (ppb/ppm) in water

1. Exposure and Risk to Nontarget Terrestrial Organisms

No avian toxicity data is available to calculate risk quotients for creosote.

Since creosote is impregnated in the wood (i.e., railroad ties, utility poles), birds and terrestrial mammals would not have easy routes of exposure. In addition, they would be able to actively avoid creosote in the environment. The occurrence of avoidance was demonstrated in two studies that showed birds avoided the consumption of food which had been mixed with creosote (Webb, 1975 and 1990). Therefore, the use of creosote as a wood preservative would not present a significant risk to birds and terrestrial mammals.

2. Exposure to Nontarget Freshwater and Marine/Estuarine Aquatic Organisms

Nontarget freshwater and marine/estuarine aquatic organisms could potentially be exposed to creosote via residues leached from treated wood into the aquatic environment. Meaningful Risk quotients (RQs) are difficult to calculate because none of the studies identified in the literature meet EPA requirements. In addition, the relevant fate studies have been conducted using individual Polycyclic Hydrocarbons (PAHs) and not on whole creosote. However, the toxicity studies reported in the literature used whole creosote and not the individual PAHs. This makes the RQs calculated using this data difficult to interpret. However, using surface water Tier II EECs for five of the PAHs found in creosote, and toxicity values from studies testing whole creosote, RQ values have been calculated and the results are presented in the following tables. A full description of the model used to obtain the EECs may be found in Appendix 10, "Environmental Modeling."

a. Freshwater Fish

Acute and chronic risk quotients are tabulated below.

Table 5: Creosote PAHs Acute Risk Quotients for Freshwater Fish Based On a Rainbow Trout LC50 of 880 ppb (most sensitive species). EECs are from GENEEC.

Site/application rate/method of application	LC50 (ppb)	EEC maximum conc. (ppb)	Acute RQ (EEC/LC50)
Fluoranthene/0.563/ pressure treated into wood	880	0.260	0.00 d
Pyrene/0.446/pressure treated into wood	880	0.130	0.00 d
Naphthalene/0.951/ pressure treated into wood	880	0.012	0.00 d
Benzo[a]pyrene/0.139/ pressure treated into wood	880	0.004	0.00 d
Chrysene/0.115/pressure treated into wood	880	0.000	0.00 d

d=No LOCs exceeded

The results indicate that none of the aquatic acute levels of concern have been exceeded by the listed application rates for each of the creosote PAHs.

Table 6: Chronic Risk Quotients for Freshwater Fish Based On a Rainbow trout NOAEC of 490 ppb.

PAH/Application rate (lb.. ai/ac/year)/Method of application	Fathead minnow NOAEC (ppb)	EEC 56-Day (ppb)	Chronic RQ Based on Rainbow trout NOAEC (EEC/NOAEC)
Fluoranthene/0.563/pressure treated into wood	490	0.017	0.00 d
Pyrene/0.446/pressure treated in wood	490	0.014	0.00 d
Benzo[a]pyrene/0.139/pressure treated into wood	490	0.0018	0.00 d
Naphthalene/0.951/pressure treated into wood	490	0.0004	0.00 d
Chrysene/0.115/pressure treated into wood	490	0.00	0.00 d

d=No LOCs exceeded

The results indicate that none of the aquatic chronic levels of concern have been exceeded for the creosote PAHs at the listed application rates.

b. Freshwater Invertebrates

The acute and chronic risk quotients are tabulated below.

Table 7: Risk Quotients for Freshwater Invertebrates Based on a *Daphnia magna* LC50 of 1930 ppb.

PAH/Application rate(lb. ai/ac/year)/ method of application	LC50 (ppb)	NOAEC (ppb)	EEC maximum conc. (ppb)	EEC 21-Day (ppb)	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOAEC)
Fluoranthene/ 0.563/pressure treated into wood	1930	NA	0.26	0.05	0.00 d	NA
Pyrene/0.446/ pressure treated into wood	1930	NA	0.13	0.04	0.00 d	NA
naphthalene/ 0.951/pressure treated into wood	1930	NA	0.01	0.00	0.00 d	NA
Benzo[a]pyrene/ 0.139/pressure treated into wood	1930	NA	0.00	0.00	0.00 d	NA
Chrysene/0.115/ pressure treated into wood	1930	NA	0.00	0.00	0.00 d	NA

d= no LOCs exceeded
NA=not available

The results indicate that none of the aquatic acute levels of concern have been exceeded for freshwater invertebrates at the listed application rates. The chronic RQs could not be calculated due to a lack of acceptable chronic toxicity data.

c. Estuarine and Marine Fish

The acute risk quotients for estuarine and marine fish are tabulated below.

Table 8: Acute Risk Quotients for Marine/Estuarine Fish Based on a Sheepshead Minnow LC50 of 720 ppb.

PAH/Rate lbs ai/A/year/method of application	LC50 (ppb)	EEC maximum conc. (ppb)	Acute RQ (EEC/LC50)
Fluoranthene/ 0.563/ pressure treated into wood	720	0.26	0.00 d
Pyrene/0.446/ pressure treated into wood	720	0.13	0.00 d
Naphthalene/ 0.951/pressure treated into wood	720	0.01	0.00 d
Benzo[a]pyrene/ 0139/pressure treated into wood	720	0.00	0.00 d
Chrysene/0.115/ pressure treated into wood	720	0.00	0.00 d

d=no LOCs exceeded

The results indicate that the none of the aquatic acute levels of concern for marine/estuarine fish is exceeded for any of the PAHs of creosote using the listed application rates.

Chronic risk to marine/estuarine fish from creosote cannot be assessed at this time due to a lack of early life-stage or life-cycle data.

d. Estuarine and Marine Invertebrates

The acute risk quotients for aquatic invertebrates are tabulated below.

Table 9: Acute Risk Quotients for Marine/Estuarine Invertebrates Based on a Mysid LC50 of 0.7 ppb.

PAH/Rate lbs ai/A/year/method of application	LC50 (ppb)	EEC maximum conc. (ppb)	Acute RQ (EEC/LC50)
Fluoranthene/ 0.563/pressure treated into wood	18	0.26	0.01 d
Pyrene/0.446/ pressure treated into wood	18	0.13	0.01 d
Naphthalene/ 0.951/pressure treated into wood	18	0.01	0.00 d
Benzo[a]pyrene/ 0.139/pressure treated into wood	18	0.00	0.00 d
Chrysene/0.115/ pressure treated into wood	18	0.00	0.00 d

d=no LOCs exceeded

The results indicate that the aquatic acute high risk level of concern has not been exceeded for marine/estuarine invertebrates for the listed applications of each PAH.

The chronic RQs for marine/estuarine invertebrates could not be calculated based on a lack of acceptable data.

3. Exposure and Risk to Nontarget Plants

The use of creosote as a wood preservative is unlikely to result in significant exposure for terrestrial plants, so risk to these organisms is expected to be minimal. RQs could not be calculated due to a lack of terrestrial plant toxicity data.

Aquatic plants could potentially be exposed to creosote via residues leached from treated wood into the aquatic environment. RQs could not be calculated because no aquatic plant toxicity data were available.

4. Endangered Species

The Agency has developed the Endangered Species Protection Program to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that address these impacts. The Endangered Species Act requires federal agencies to ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat. To analyze the potential of registered pesticide uses to affect any particular species, EPA puts basic toxicity and exposure data developed for risk assessments into context for individual listed species and their locations by evaluating important ecological parameters, pesticide use information, the geographic relationship between specific pesticide uses and species locations, and biological requirements and behavioral aspects of the particular species. A determination that there is a likelihood of potential impact to a listed species may result in limitations on use of the pesticide, other measures to mitigate any potential impact, or consultations with the Fish and Wildlife Service and/or the National Marine Fisheries Service as necessary.

The Agency is currently engaged in a Proactive Conservation Review with USFWS and the National Marine Fisheries Service under section 7(a)(1) of the Endangered Species Act. The objective of this review is to clarify and develop consistent processes for endangered species risk assessments and consultations. Subsequent to the completion of this process, the Agency will reassess the potential effects of creosote use to federally listed threatened and endangered species. Until such time as this analysis is completed, the overall environmental effects mitigation strategy articulated in this document and any County Specific Pamphlets described in Section 7 of the Endangered Species Act which address creosote or other wood preservatives will serve as interim protection measures to reduce the likelihood that endangered and threatened species may be exposed to creosote at levels of concern.

D. Risk Characterization

The lack of toxicity data for wildlife and plants makes the toxicity of creosote to the organisms difficult to characterize. Literature studies indicate that birds will avoid consumption of creosote-contaminated food items. Rat and mouse studies conducted for human risk assessment purposes indicate a low to moderate acute oral toxicity to those species. Data from the open literature indicate high to very high acute toxicity of creosote to freshwater fish, high acute toxicity to marine/estuarine fish, high acute toxicity to freshwater invertebrates, and high to very high acute toxicity to marine/estuarine invertebrates. However, as described in the toxicity data sections above, lack of measurement of the actual concentrations to which fish and aquatic invertebrates were exposed in these studies could lead to a substantial underestimation of the toxicity of creosote to those organisms.

Chronic toxicity information was only available for freshwater invertebrates and marine/estuarine fish. The invertebrate study, conducted with *Daphnia magna*, showed reproductive impairment and reduction in growth at 1.0 % of the water soluble fraction (WSF) of creosote; there was not enough information in the published report, however, to translate that level into a water concentration for creosote, so a quantitative estimate of risk could not be calculated. The results do indicate the potential of creosote to be an endocrine disruptor. Likewise, the marine fish chronic hazard information in the open literature also suggests endocrine-disrupting potential for creosote. Bottom-dwelling fish have shown reduced gonadal development, reduction of endogenous estradiol concentrations during pregnancy, inhibited spawning ability, reduced egg and larval viability, and lowered spawning success. These effects have been observed in the field as well as in the laboratory. There is no information regarding water concentrations of creosote in these studies, however, that would enable the Agency to calculate a RQ for these types of effects.

EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally-occurring estrogen, or other such endocrine effects as the Administrator may designate." Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was scientific basis for including, as part of the program, the androgen and thryoid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use FIFRA and, to the extend that effects in wildlife may help determine whether a substance may have an effects in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP). When the appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, creosote may be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption

Most of the ecotoxicity data found in the open literature for creosote has limited usefulness in a risk assessment, due to the lack of measured concentrations and other quantifiable parameters. Such studies were not conducted to meet Agency guideline requirements; however, we have made inferences about the results to fit data requirements. Additionally, the specific composition of the creosote used in the studies was not given by the researchers. This made it difficult to compare the results of different studies and to relate these results to environmental fate information used to calculate estimated exposure. Further complicating matters, the environmental fate data were developed for the component polycyclic aromatic hydrocarbons (PAHs) and not for whole creosote, again making it difficult to relate the exposure and effects results, particularly in calculating Risk Quotients (RQs).

The Agency has concluded that risk to birds and terrestrial mammals is likely to be minimal, due to lack of exposure and the ability of these organisms to avoid creosote. Risk to terrestrial plants would also be considered minimal due to lack of exposure. However, risk to freshwater and marine/estuarine aquatic organisms is harder to quantitate using these data. Certainly there will be some exposure due to leaching from the treated wood into the aquatic environment; however, determining the amount of exposure and the amount of toxicity due to this exposure is difficult using the data at hand. The RQ values calculated with the available data do not demonstrate a concern for acute effects on aquatic organisms or chronic effects on freshwater fish. However, the EECs were calculated for the component PAHs, while the aquatic toxicity data were generated using whole creosote. The available data found in the open literature were not adequate to supply the information needed to assess chronic effects to freshwater invertebrates or to marine/estuarine aquatic organisms. It is not possible, therefore, to determine the chronic risk creosote may present to freshwater invertebrates and marine/estuarine aquatic organisms. However, the data indicate that creosote does not exceed the level of concern for acute toxicity to fish and aquatic invertebrates or for chronic toxicity to freshwater fish.

Data Gaps and Uncertainty in this Risk Assessment

A memo from the Environmental Fate and Effects Division (EFED), dated 4/12/95, stated that "it would be more useful to the Agency for the registrant to satisfy the ecotoxicity data requirements via a literature search rather than addressing these requirements based on the limitations of the basic data set" required at the time. Therefore, data identified in the open literature were used in making this risk assessment. There is much uncertainty in this risk assessment, however, due to the following:

1. Lack of any toxicity data for birds, mammals, or terrestrial plants

2. Lack of chronic (early life-stage or life-cycle) data for freshwater invertebrates, marine/estuarine fish, and marine/estuarine invertebrates

3. Literature studies did not report actual measured concentrations of creosote in aquatic studies, so the reported toxicity may be substantially underestimated. This in turn could result in the risk to these organisms being substantially underestimated.

4. The available environmental fate and exposure data are for individual PAHs. The available toxicity data is for whole creosote. The differences in the toxicity of whole creosote compared to that of individual PAHs has not been addressed in the literature, so a direct comparison between them in a risk quotient, as was used in this risk assessment, may introduce a high degree of uncertainty into the risk assessment.

Toxicity studies conducted with creosote according to Guideline requirements would remove some of the uncertainty in this risk assessment. However, the environmental fate and exposure issues for whole creosote versus the individual PAHs need to be characterized before appropriate toxicity testing can be conducted.

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